



NASA-STD-6016

Standard Materials and Processes Requirements for Spacecraft

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- Provides minimum requirements for Materials and Processes (M&P) used in design, fabrication, and testing of flight components for NASA manned, unmanned, robotic, launch vehicle, lander, in-space and surface systems, and spacecraft program/project hardware elements

■ Requirements may be tailored for specific programs/projects

- Tailoring could include using existing or previously developed contractor processes and standards



Requirements for Materials



- Selection by consideration of worst-case operational requirements and design engineering properties of candidate materials

Operational requirements

- Temperature limits
- Loads
- Contamination
- Life expectancy
- Moisture or other fluid media exposure
- Vehicle-related induced and natural space environments



Engineering Properties



- Flammability and toxic offgassing
- Corrosion
- Stress corrosion
- Thermal and mechanical fatigue
- Glass-transition temperature
- Coefficient of thermal expansion mismatch
- Vacuum outgassing
- Fluids compatibility
- Microbial resistance



Engineering Properties



- Moisture resistance
- Fretting
- Galling
- Susceptibility to electrostatic discharge (ESD)
- Susceptibility to contamination



General Requirements



- Materials and processes selection, control, and implementation plan
- Coordination, approval, and tracking of engineering drawings, engineering orders, and other documents that establish or modify materials and/or processes
- Specify approval process
- Materials and processes controls
- Updating, alternating, or using new materials or processes
- Commercial Off-The-Shelf Hardware (COTS)



General Requirements



- Materials and processes usage documentation
 - Materials Identification and Usage List (MIUL)
- Human-rated and non-human-rated spacecraft
- Materials Usage Agreements (MUAs) – submitted for M&P that are technically acceptable, but do not meet requirements of the approved M&P selection, control, and implementation plan
- Manufacturing planning
- Materials certification and traceability
- Materials design allowables



Detailed Requirements



- Flammability, offgassing, and compatibility requirements
 - Flammability control
 - Toxic offgassing
 - Fluid compatibility
 - Electrical wire insulation materials

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Metals



- Aluminum
- Steel
- Titanium
- Magnesium
- Beryllium
- Cadmium
- Zinc
- Mercury
- Refractory metals
- Superalloys (Nickel-based and Cobalt-based)
- Tin



Nonmetallic Materials



- Elastomeric materials
- Polyvinylchloride
- Composite materials
- Lubricants
- Limited-life items
- Thermal vacuum stability
- External environment survivability
- Fungus resistance
- Glycols
- Etching fluorocarbons



Processes



- Forging
- Castings
- Adhesive bonding
- Welding
- Brazing
- Structural soldering
- Electrical discharge machining and laser machining



Material Nondestructive Inspection (NDI)



- Nondestructive evaluation (NDE) plan
- NDE etching
- Nickel plating

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Special Materials Requirements



- Residual stresses
- Sandwich assemblies
- Corrosion prevention and control
 - Passivation
 - Sealing
- Hydrogen embrittlement
- Fastener installation
 - Liquid locking compounds
 - Silver-plated fasteners
- Contamination control
- Packaging

